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(71) Applicant: **Black & Decker Inc.**
Newark Delaware 19711 (US)

(72) Inventors:
- **Moores, Robert G. Jr.**
  Reiterstown, Maryland 21136 (US)
- **Cochran, John R.**
  Baltimore, Maryland 21234 (US)
- **Bailey, Rouse R. Jr.**
  New Park, Pennsylvania 17352 (US)
- **Ramstrom, Lee W.**
  Hunt Valley, Maryland 21030 (US)
- **Bradus, Robert**
  Bel Air, Maryland 21015 (US)
- **Kreiser, Douglas L.**
  Baltimore, Maryland 21234 (US)

(74) Representative: **Dlugosz, Anthony Charles et al**
Black & Decker Europe European Group
Headquarters 210 Bath Road
Slough, Berkshire SL1 3YD (GB)

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(54) Battery cooling system

(57) A battery charger for a chargeable battery pack (26) of a cordless power tool (20) comprising a charger housing (160), contacts (162) for electrically coupling with the battery pack (26) which battery pack has a battery housing (34) with a vent system (38) for enabling air to pass through said battery housing and a power source coupled with said contacts. A fan (182) in the charger housing is provided for forcing air through said vent system (38) of the battery housing in order to cool the battery pack.

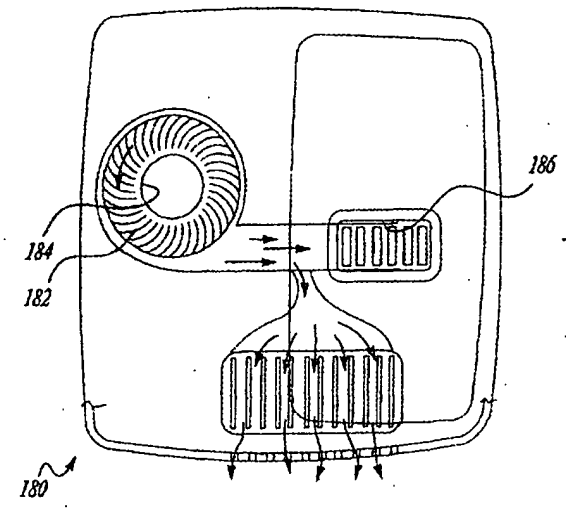

Fig-11

EP 1 178 557 A2

Battery cooling system

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Inventor:	BAILEY ROUSE R JR (US); KREISER DOUGLAS L (US); BRADUS ROBERT (US); COCHRAN JOHN R (US); RAMSTROM LEE W (US); MOORES ROBERT G JR (US)
Applicant:	BLACK & DECKER INC (US)
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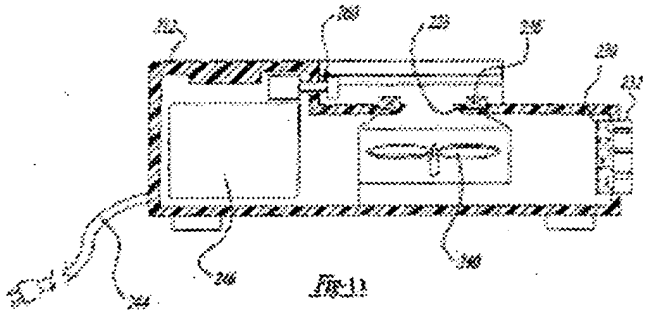
Abstract of **EP1178557**

A battery charger for a chargeable battery pack (26) of a cordless power tool (20) comprising a charger housing (160), contacts (162) for electrically coupling with the battery pack (26) which battery pack has a battery housing (34) with a vent system (38) for enabling air to pass through said battery housing and a power source coupled with said contacts. A fan (182) in the charger housing is provided for forcing air through said vent system (38) of the battery housing in order to cool the battery pack.



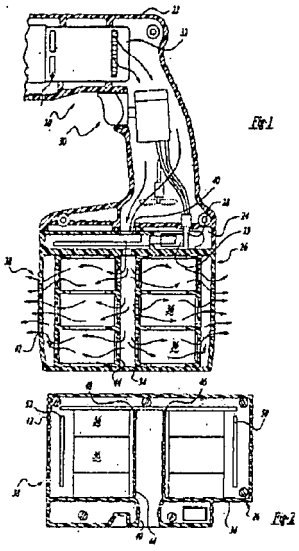


Fig.1

Fig.2

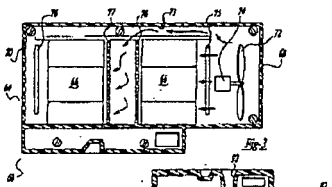


Fig.3

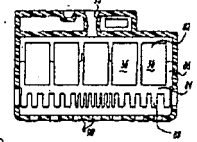


Fig.4a

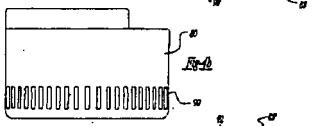


Fig.4b

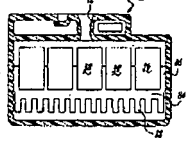


Fig.4c

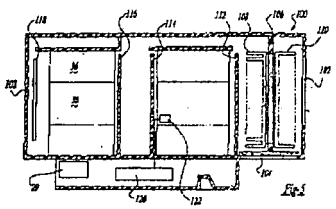


Fig.5

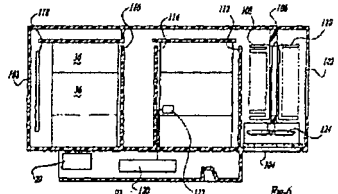


Fig.6

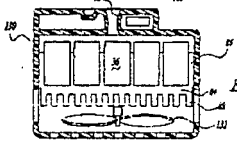


Fig.7

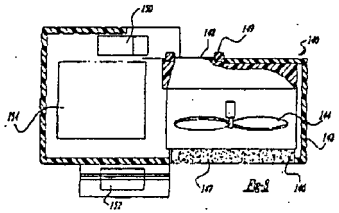


Fig.8

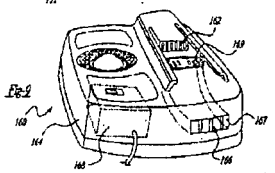


Fig.9

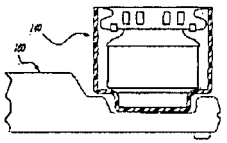


Fig.10

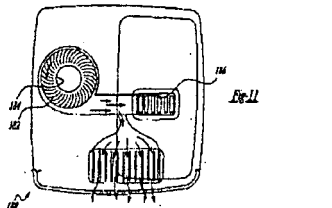


Fig.11

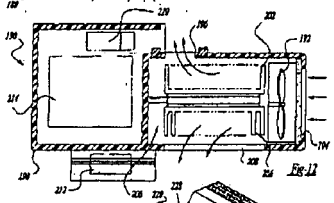


Fig.12

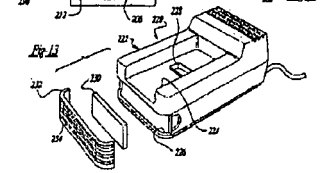


Fig.13

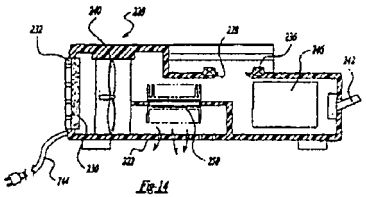


Fig.14

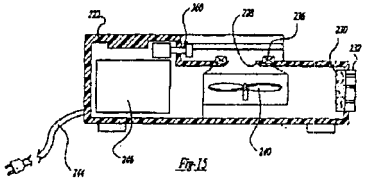


Fig.15

Battery cooling system

Description of **EP1178557**

[0001] The present invention relates to battery cooling systems for cordless power tools.

[0002] Cordless products which use rechargeable batteries are prevalent throughout the workplace as well as in the home. From housewares to power tools, rechargeable batteries are used in numerous devices. Ordinarily, nickel-cadium or nickelmetalhydride battery cells are used in these devices. Since the devices use a plurality of battery cells, the battery cells are ordinarily packaged as battery packs. These battery packs couple with the cordless devices and secure to the device. The battery pack may be removed from the cordless device and charged in a battery charger or charged in the cordless device itself.

[0003] As the cordless power device is used, current flows through the batteries to power the cordless device. As current is drawn off the batteries, heat is generated within the battery pack. Also, during charging of the battery pack, heat is likewise accumulated during the charging process. The heat created during discharge of the batteries as well as charging of the batteries which, in turn, leads to increased temperatures, may have a severe effect on the life expectancy and performance of the batteries. In order for batteries to properly charge, the batteries must be below a desired threshold temperature and the differential temperature between the cells in the battery pack should be minimised. Likewise, if the batteries become too hot during use, battery life will be cut short. Also, if a battery is below a certain threshold temperature, it will be too cold to charge and must be warmed before charging. Thus, it is desirous to maintain batteries within a desired temperature range for optimum performance as well as optimum charging.

[0004] Further, battery packs typically contain some battery cells close to the outer walls of the pack, while some battery cells are surrounded by other battery cells. Those cells close to the outer walls have better thermal conductivity to the outside ambient than do the cells that are surrounded by other cells. When a battery pack is discharging on the cordless device, the amount of heat generated is approximately the same in each cell. However, depending on the thermal path to ambient, different cells will reach different temperatures. Further, for the same reasons, different cells reach different temperatures during the charging process. Accordingly, if one cell is at an increased temperature with respect to the other cells, its charge or discharge efficiency will be different, and, therefore, it may charge or discharge faster than the other cells. This will lead to a decline in the performance of the entire pack.

[0005] In accordance with a first aspect of the invention, there is provided a battery charger for a chargeable battery pack of a cordless power tool comprising:

a charger housing;
contacts for electrically coupling with the battery pack which battery pack has a battery housing with a vent system for enabling air to pass through said battery housing;
a power source coupled with said contacts; characterized by;
a fan in the charger housing for forcing air through said vent system of the battery housing.

[0006] The fan may be coupled with a vent system of the charger and the charger vent system has an inlet and an outlet to enable air to pass into and through the battery charger and in turn into the battery pack vent system.

[0007] According to a second aspect of the present invention there is provided a cordless power tool, which comprises a tool housing including a mechanism for coupling with a removable battery pack, which includes a battery charger for charging said battery pack, said battery pack comprising:

a battery housing with one or more cells in the housing;
a vent system in said battery housing for enabling air to pass through said housing; and
a mechanism associated with said battery pack for dissipating heat in said battery pack,
characterised by said battery charger having a fan for forcing air through said vent system of said battery pack.

[0008] The mechanism for dissipating heat in the battery pack may include fluid directors for moving air to one or more cells of the battery pack. The mechanism for dissipating heat in the battery pack may also include a metallic heat sink for dissipating heat from said one or more cells. A mechanism may be provided in said battery housing coupled with said plurality of cells for equalizing temperature of said plurality of cells. The mechanism may be a heat sink for equalizing temperature of said cells in said housing. The heat sink may include an increased concentration of material in the areas having higher temperature cells. The heat sink may include a thermal conductive medium surrounding said cells, a base, and fins.

[0009] In accordance with further aspects of the invention, several of the above features may be combined with one another to provide additional advantages. Additional objects and advantages of the invention will become apparent from the detailed description of the preferred embodiment, and the appended claims and accompanying drawings, or may be learned by practice of the invention.

[0010] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention and together with the description serve to explain the principles of the invention. In the drawings, the same reference numerals indicate the same parts.

[0011] Figure 1 is a partial cross-section view of a cordless power tool and battery in accordance with the present invention.

[0012] Figure 2 is a partial cross-section view of a battery pack in accordance with the present invention.

[0013] Figure 3 is a cross-section view of another embodiment of a battery pack in accordance with the present invention.

[0014] Figure 4A is a cross-section view of another battery pack in accordance with the present invention.

[0015] Figure 4B is an elevation view of the battery pack of Figure 4A.

[0016] Figure 4C is a cross-section view of another battery pack in accordance with the present invention.

[0017] Figure 5 is another cross-section view of a battery pack in accordance with the present invention.

[0018] Figure 6 is an additional cross-section view of another embodiment of a battery pack in accordance with the present invention.

[0019] Figure 7 is an additional cross-section view of a battery pack in accordance with the present invention.

[0020] Figure 8 is a cross-section view of an auxiliary fan module in accordance with the present invention.

[0021] Figure 9 is a perspective view of a charger in accordance with the present invention.

[0022] Figure 10 is a cross-section view of the auxiliary fan module coupled with the charger of Figure 9 in accordance with the present invention.

[0023] Figure 11 is a cross-section view of another embodiment of the present invention of a charger of Figure 9.

[0024] Figure 12 is a cross-section view like that of Figure 8 of another embodiment of an auxiliary fan in accordance with the present invention.

[0025] Figure 13 is a perspective view of a battery cooler/heater in accordance with the present invention.

[0026] Figure 14 is a longitudinal cross-section view of Figure 13.

[0027] Figure 15 is a view like Figure 14 of an additional embodiment of the battery cooler/heater.

[0028] Turning to the figures, a cordless device is illustrated and designated with the reference numeral 20. The cordless device ordinarily includes a clamshell type housing 22. The housing 22 includes a mechanism 24 to couple with a portion of a battery pack 26. The cordless device 20 includes electrical elements 28 which couple with the battery pack electrical elements 29. Also, the device includes a trigger 30 which energizes the motor 32 within the housing 22.

[0029] The battery pack 26 includes a housing 34 which contains a plurality of battery cells 36 within the housing 34. Also, the housing 34 includes a ventilation system 38 which enables fluid to pass through the housing 34 and move around the cells 36 to dissipate heat from the plurality of cells 36 to the ambient air. The venting system 38 ordinarily includes at least one inlet 40 and at least one outlet 42. The inlet and outlet are ordinarily apertures or slots in the housing 34, Also, a channel 44 is formed within the housing 26 and aligned with the inlet 40 to distribute the fluid flow around the battery cells 36 so that all of the battery cells 36 are cooled. Preferably, the fluid flows coaxially with respect to the axes of the batteries 36. Thus, as fluid enters into the channel 44, the fluid is directed over the battery cells and does not pass over one cell to the next cell, etc., but is passed over a number of cells at one time so that the fluid passing through the housing is not warmed by the first cell and then passed over the second cell. However, fluid could be passed over the battery cells transversely with respect to the battery cells axes.

[0030] Turning to Figure 2, an additional embodiment of a battery pack is shown. The battery pack 26 is like that illustrated in Figure 1, including the housing 34, ventilation system 38 with inlet 40 and outlet 42. Also, cells 36 are positioned within the housing. Additionally, the battery pack includes one or more baffles 46, 48, 50 and 52. The baffles direct the fluid to specific battery cells 36. Ordinarily, the fluid is passed into channel 44 and distributed through the baffles 46 and 48.

[0031] Turning to Figure 3, an additional embodiment of a battery pack is shown. Battery pack 60 includes a housing 62 with a venting system 64 which enables fluid to pass around the battery cells 66. The ventilation system 64 includes at least one inlet 68 and at least one outlet 70. Also, the battery housing includes a fan 72. The fan 72 may include a motor 74 which may run off of the battery cells 36. Also, the fan motor 74 may run off of a charging circuit when the battery pack is in a charger. The fan 72 moves fluid through the battery pack inlet. The fluid is forced over the battery cells 66 and out the outlets 70. Thus, a positive pressure is created in the battery pack as fluid flows through the battery pack 60. However, a negative pressure could be created in the battery pack sucking fluid through the battery pack. The channels 73 direct the fluid through the battery cells so that the fluid does not continue to pass from cell to cell but passes over different cells so that the cells experience the air at about the same temperature.

[0032] Also, the battery housing may include baffles 75, 76, 77, 78 like those described above.

[0033] Further, an auxiliary fan could be positioned in the tool housing itself as illustrated in phantom in Figure 1 to move fluid through the battery housing. Temperature sensors may be positioned in the housing to monitor individual battery cell temperature. Also, the baffles may be designed to direct fluid flow to the hottest battery cells. Thus, the cells would be cooled as well as the temperature being equalized.

[0034] Turning to Figures 4A and 4B, an additional embodiment of the present invention is illustrated. Here, the battery pack includes a housing 80, a plurality of cells 36 which are wrapped in a thermally conductive but electrically insulating substance 83 to remove heat from the battery pack. Also, a heat sink 84 is positioned between the cells for wicking the heat from the battery cells 36. Projecting portions 86 surround the batteries to effectively move heat towards the fins 88 of the heat sink 84. Also, a plurality of slots 90 are formed in the housing 80 to enable the heat to be removed from the battery cells 36. The heat sink 84 may be any type of metallic sink with the projecting portion 82 either being metallic or a thermally conductive medium, such as potting compound, gels or grease to extract the heat from the cells to the heat sink 84. The heat exits through the fins 88. Also, more fins, as well as larger projecting portions, surround battery cells which are known to have higher temperatures during charging of the battery as well as discharging when the tool is used. Thus, heat is drawn from the battery cells 36 to the heat sink. The ventilation slots 90 enable fluid to pass over the fins 88 to remove heat. Also, an inlet 92 may be included in the housing to enable fluid to pass from a fan in the tool housing through the battery pack.

[0035] Figure 4C illustrates an additional embodiment of the present invention. The battery pack is similar to that in Figures 4A and 4B, except the housing 80 &squ& does not include the plurality of slots. The plurality of cells 36 are wrapped in a thermally conductive but electrically insulating substance such as tape 83 to enable heat to move from battery to battery via a heat sink 84. The heat sink 84 is positioned

between the cells to wick heat from hotter battery cells and transfer the heat to battery cells having a lower temperature so that the temperatures of the cells are equalized within the pack. Projecting portions 86 surround the battery cells to effectively remove heat towards the fins of the heat sink 84. Cells which are known to have higher temperatures are designated with 36 &squ& . Further, the heat sink may be a metallic type like that mentioned above, or may include thermally conductive mediums such as potting compound, gels or grease to extract heat from hotter cells and move it to the heat sink which, in turn, distributes the heat to the remaining cells such that the temperature within the cells is equalized. Thus, the temperature equalization of the cells enables the cells to be charged and discharged at a substantially equal rate which improves and increases the life of the battery pack.

[0036] Turning to Figure 5, an additional embodiment is illustrated. In Figure 5, the battery pack includes a housing 100 surrounding a plurality of cells 36. The housing 100 includes a plurality of slots 102 which act as outlets and an inlet 104. Also, a heat pump 106 is positioned within the housing 100. The heat pump 100 is a Peltier device, which is commonly known in the art. The Peltier device is coupled with heat sinks 108 and 110, As the Peltier device is activated, one heat sink becomes cold while the other becomes hot. If the current through the Peltier device is reversed, the cold and hot sides reverse. Thus, the heat sinks 108, 110 can be used to provide cool air into the battery housing 100 and enable the air to be baffled by baffles 112, 114, 116 and 118 to pass over the battery cells 36 and exit the housing through the outlet slots. Thus, cool air would be passed into the housing to cool the batteries. In the event that the battery cells are cold, the Peltier device current could be reversed wherein heated fluid would be passed through the battery pack to warm the battery cells so that they could be charged. The Peltier device is coupled to electronics 120 which may function off of the battery cells, a charger, or both, to control the cooling or heating. Also, a temperature sensor 122 may be positioned in the housing, with respect to the battery cells, so that heating and cooling may take place as desired.

[0037] Figure 6 is a view like that of Figure 5 including the heat pump 106. Additionally, a fan 124 is positioned within the housing to move the fluid through the battery pack 100. Here, fluid can be channeled throughout the battery enabling the battery to be cooled.

[0038] Turning to Figure 7, a battery pack is illustrated and designated with the reference numeral 130. Here, the battery pack is similar to that illustrated in Figure 4, however, a fan 132 is positioned within the battery pack. The fan 132 moves fluid across the fins 88 in an attempt to expel the heat from the battery pack housing 130.

[0039] Turning to Figure 8, an auxiliary fan module is illustrated and designated the reference numeral 140. The auxiliary fan module 140 includes a housing 142 which houses a fan 144. The housing includes an inlet 146 as well as an outlet 148. Fluid flows through the outlet 148, which is surrounded by seal 149, into the battery pack inlet 40 like that illustrated in Figures 1, 2. Electrical contacts 150 are positioned within the housing 142 to couple with the battery electrical contacts 29 to charge the battery cells 36. Further, electrical contacts 152 are secured with the housing 142 to mate with electrical contacts in a charger to run the fan during charging of the battery cells. Further, an electronic package 154 is within the housing 142 to control charging of the battery as well as operation of the fan 144. The electronic package 154 may be coupled with the temperature sensor to operate the fan as needed.

[0040] Turning to Figure 9, a perspective view of a battery charger is illustrated and designated with the reference numeral 160. The charger 160 includes contacts 162 to couple with a battery pack or auxiliary fan module to charge a battery pack. The charger 160 includes a base 164 which includes the electrical contacts coupled with the base. Further a vent system 166, with inlet 167 and outlet 169, is coupled with the base 164 to enable air to pass into and through the battery charger and in turn the battery pack. Further, the battery charger includes an electronics package 168 which receives the current from an AC source and converts it into the DC source required to charge the battery pack.

[0041] The charger 160 may be utilized with the disclosed battery packs with or without fans in the battery pack. In the event a battery pack is used which does not include a fan, convection would be used to enable air flow through the vent system 160 and in turn through the battery pack. In a situation where the battery pack includes a fan, the contacts 162 would also couple with the fan electronics within the battery pack to for operating the fan. In this event, the electronics in the charger would electrically couple with the fan electronics to turn on and turn off the fan when needed.

[0042] Also, the charger could be utilized with the auxiliary fan module 140 as illustrated in Figure 10. Here, the auxiliary fan module 140 is coupled with the electrical contacts 162 in the charger 160 to operate

the fan 144 within the auxiliary fan module 140. Accordingly, the fan 144 may be turned on and off as desired.

[0043] Turning to Figure 11, a charger 180 is shown. The charger 180 is similar to the battery charger 160 except that the battery charger 180 includes a fan 182 coupled with the venting system 166. The fan 182 moves fluid through an inlet 184 and forces the fluid through an outlet 186 into the battery pack. In this type of charger 180, the fan 182 would be activated as desired. Further, the charger electronics could be coupled with a sensor inside of the battery pack which would be activated through the electrical contacts 162. The sensor would sense the temperature within the battery pack so that the fan could run intermittently. Also, the sensors may be removed and the fan would just run constantly while the charger is operating.

[0044] Turning to Figure 12, an auxiliary fan module is illustrated like that in Figure 8. Here, the auxiliary fan module 190 includes a fan 192, an inlet 194 and an outlet 196 in the housing 198. Also, a heat pump 200 as described above is positioned within the housing 198. The heat pump would produce a cold heat sink 202 which would enable fluid to move in to the housing, via the fan, and pass over the cold heat sink and into the battery pack. The fluid would also pass over the hot side of the heat sink 206, withdrawing heat from the housing, and exhausting the air to ambient through outlet 208. In the event the battery pack is cold, the heat pump 200 may be reversed and heat may be passed into the battery pack to warm the battery pack before charging. The fan module 190 also includes electrical contacts 210 to couple with the battery pack. Also, electrical contacts 212 couple with the charger 160. The electronics 214 within the auxiliary fan module 190 couple with the charger and operate the fan to move fluid into the battery pack as desired.

[0045] Turning to Figures 13-15, additional embodiments of the present invention are shown. Figure 13 illustrates a perspective view of a battery cooler/heater device. Here, the battery cooler/heater 220 includes a housing 222. The housing 222 includes a battery receiving portion 224. The battery receiving portion 224 may be a cutout or the like in the battery housing 222 forming a depression to receive a battery housing pack. Further, the housing includes an inlet 226 and an outlet 228. The inlet enables fluid to pass into a duct in the housing 222 while the outlet enables the fluid to be passed out of the housing duct and into a battery pack. The inlet 226 is generally covered by a filter 230 and a grill 232 is attached to the housing 222 sandwiching the filter between the inlet and the grill 232. The grill 232 has slots 234 to enable air to pass through the grill into the filter and turn through the inlet 226.

[0046] An O-ring or some type of seal 236 is positioned around the outlet 228 as shown in Figure 14. The seal 236 mates with the battery pack to prohibit fluid from escaping around the battery pack housing while fluid is passed into the battery pack housing.

[0047] In Figure 14, the housing 222 includes a fan 240 to move fluid between the inlet 226 and outlet 228. The fan 240 is energized and de-energized by a switch 242. In Figure 14, the switch 242 is a manual switch enabling the user to manually turn on and turn off the fan 240 as desired. Also, a power cord 244 is coupled with the fan and switch electronics 246 to provide power to the battery cooler/heater 220.

[0048] Additionally, a Peltier device 250 (illustrated in phantom) may be positioned near the inlet which may provide cooled or heated fluid which is drawn into the battery pack as described above. The Peltier device 250 would be coupled with the electronics 246 so that the Peltier device 250 may deliver cold or hot fluid flow, depending upon if cooling or heating is desired, to the battery cells.

[0049] Turning to Figure 15, an additional embodiment of the battery heater/cooler 220 is shown. Here, the battery cooler is like that described above, except that an automatic switch 260 has replaced the manual switch 242. Here, as the battery pack housing is slid into the battery cooler/heater housing, the battery contacts the normally open switch 260 energizing the fan 240. As the battery pack housing is withdrawn from the battery cooler/heater, the switch 260 would return to its normally open position, de-energizing the fan.

[0050] As will be appreciated by those skilled in the art, the present invention provides the art with a battery pack which dissipates heat within the battery pack during charging of the cells as well as discharging of the cells while the battery pack is in use. Additionally, the invention provides auxiliary devices for aiding the changing of the battery pack temperature for optimizing charging of the pack. In accordance with the various aspects of the invention, the battery pack life can be increased, battery pack performance can be enhanced and charging time can be reduced.

[0051] While the above detailed description describes the preferred embodiment of the present invention, the invention is susceptible to modification, variation, and alteration without deviating from the scope and fair meaning of the subjoined claims.

Battery cooling system

Claims of **EP1178557**

1. A battery charger for a chargeable battery pack (26) of a cordless power tool (20) comprising:

a charger housing (160);
contacts (162) for electrically coupling with the battery pack (26) which battery pack has a battery housing (34) with a vent system (38) for enabling air to pass through said battery housing;
a power source coupled with said contacts; characterized by;
a fan (182) in the charger housing for forcing air through said vent system (38) of the battery housing.

2. A battery charger according to claim 1, wherein the fan (182) is coupled with a vent system (166) of the charger.

3. A battery charger according to claim 2, wherein the charger vent system (166) has an inlet (167) and an outlet (169) to enable air to pass into and through the battery charger and in turn into the battery pack vent system (38).

4. A battery charger according to any one of claim 1 to 3, additionally comprising an electronics package (168) which receives current from an alternating current source and converts it into a direct current source required to charge a battery pack.

5. A battery charger according to any one of the preceding claims, wherein the fan (182) can be activated as required.

6. A battery charger according to claim 4, wherein the electronics package (168) is coupled with a sensor inside of the battery pack which sensor is activated through electrical contacts (162) and the sensor senses the temperature within the battery pack and the fan (182) is run intermittently.

7. A cordless power tool (20), which comprises a tool housing (22) including a mechanism for coupling with a removable battery pack (26), which includes a battery charger (160,180) for charging said battery pack, said battery pack comprising:

a battery housing (34) with one or more cells (36) in the housing
a vent system (38) in said battery housing for enabling air to pass through said housing; and
a mechanism associated with said battery pack (26) for dissipating heat in said battery pack, characterised by said battery charger having a fan (182) for forcing air through said vent system (38) of said battery pack.

8. A cordless power tool according to Claim 7, wherein said mechanism includes fluid directors (46, 48, 50, 52) for moving air to one or more cells (36) of the battery pack.

9. A cordless power tool according to claim 7 or claim 8, wherein said mechanism includes a metallic heat sink (84) for dissipating heat from said one or more cells.

10. A cordless power tool according to anyone of claims 7 to 9, further including a heat pump (100) for providing cooling and heating of said one or more cells (36) in said battery pack housing (34).

11. A cordless power tool according to anyone of claims 7 to 10, wherein said mechanism includes fluid directors (75, 76, 77, 90) for moving air around higher temperature cells of said one or more cells.

12. A cordless power tool according to claim 7, comprising a mechanism (84) in said battery housing coupled with said plurality of cells for equalizing temperature of said plurality of cells (36).

13. A cordless power tool according to claim 12, wherein said mechanism coupled with said cells includes a heat sink (84) for equalizing temperature of said cells in said housing.

14. A cordless power tool according to claim 13, wherein said heat sink has an increased concentration (88) in the area having higher temperature cells.

15. A cordless power tool according to claim 13 or 14, wherein said heat sink includes a thermal conductive medium (86) surrounding said cells, a base, and fins (88).

16. A cordless power tool according to claim 7 wherein the battery charger comprises:

a charger housing (160);
contacts (162) for electrically coupling with the battery pack (26); and
a power source coupled with said contacts.

17. A cordless power tool according to claim 16, wherein the fan (182) is coupled with a vent system (166) of the charger.

18. A cordless power tool according to claim 17, wherein the charger vent system (166) has an inlet (167) and an outlet (169) to enable air to pass into and through the battery charger and in turn into the battery pack vent system (38).

19. A cordless power tool according to any one of claims 16 to 18, additionally comprising an electronics package (168) which receives current from an alternating current source and converts it into a direct current source required to charge a battery pack.

20. A cordless power tool according to any one of claims 16 to 19, wherein the fan (182) can be activated as required.

21. A cordless power tool according to claim 19, wherein the electronics package (168) is coupled with a sensor inside of the battery pack which sensor is activated through electrical contacts (162) and the sensor senses the temperature within the battery pack and the fan (182) is run intermittently.